National Superconducting Cyclotron Laboratory
Proposal Form—PAC 35

TITLE: _______ Study of ^{5}H with the ^{6}He(d,^{3}He)^{5}H reaction ___

By submitting this proposal, the spokesperson certifies that all collaborators listed have read the proposal and have agreed to participate in the experiment.

SPOKESPERSON: ___ Alan Wuosmaa___

Address: _Department of Physics, Western Michigan University___

1903 W. Michigan Ave. MS 5252, Kalamazoo MI 49008-5252___

Phone: _269-387-4911___ Fax: : _269-387-4939___ E-Mail : alan.wuosmaa@wmich.edu

BACKUP SPOKESPERSON: ____Shadi Bedoor___

Institution: _______Department of Physics, Western Michigan University

1903 W. Michigan Ave, MS 5252, Kalamazoo MI 49008-5252___

Phone: _269-387-4946___ Fax: : 269-387-4939 E-Mail : shadi.a.bedoor@wmich.edu

OTHER EXPERIMENTERS: (Please spell out first name and indicate Graduate Students (GS), Undergraduate students (UG) and Postdoctoral Associates (PD); include a separate sheet if necessary)

Last name, First name	Organization	Last name, First name	Organization
		Lynch, William	MSU
Shetty, Dinesh (PD)	WMU	Mittig, Wolfgang	MSU
Marley, Scott (GS)	WMU	Winkelbauer, Jack (GS)	MSU
Sobotka, Lee	WU	Goldberg, Vladilen	TAMU
Charity, Robert	WU	Rigochev, Grigory	FSU
		Golovkov, Michael	Flerov Inst., Dubna

REQUEST FOR PRIMARY BEAM SEQUENCE INCLUDING TUNING, TEST RUNS, AND IN-BEAM CALIBRATIONS: (Summary of information provided on Beam Request Worksheet(s). Make separate entries for repeat occurrences of the same primary beam arising from user-requested interruptions to the experiment.)

	Isotope	Energy (MeV/nucl.)	Minimum Intensity (particle-nanoampere)	Sum of Beam Preparation Times (Hours)	Sum of Beam-On-Target Times (Hours)
Beam 1	^{18}O	120	150	12+5=17	144
Beam 2					
Beam 3					
Beam 4					

ADDITITIONAL TIME REQUIREMENTS THAT REQUIRE USE OF THE CCF (e.g. modification of the A1900 standard configuration, development of optics, … Obtain estimates from the A1900 Device Contact.)

Additional CCF use time: [ ]

Total Hours: 17 | 144

TOTAL TIME REQUEST (HOURS): _161_______
(Calculated as per item 5. of the Notes for PAC 35 in the Call for Proposals)

Access to:		SET UP TIME (before start of beam)	TAKE DOWN TIME
	Experimental Vault	____28____ days	__10______ days
	Electronics Set-up Area	____28____ days	__10______ days
	Data Acquisition Computer	____28____ days	__10______ days

NSCL PAC 35 – 3. Status of Previous Experiments

HOURS APPROVED: ________________ HOURS RESERVED: ______________________

WHEN WILL YOUR EXPERIMENT BE READY TO RUN? ___June____ / __01__/ 2011____

DATES EXCLUDED: ____

EXPERIMENTAL LOCATION:

___ Transfer Hall (in the A1900)
___ Transfer Hall (downstream of the A1900)
___ N2 vault
___ N2 vault (with Sweeper line)
___ S2 vault (Irradiation line)
_X_ S2 vault
___ S3 vault

EXPERIMENTAL EQUIPMENT:

_X_ A1900
___ Beta Counting System
___ Beta-NMR Apparatus
___ Sweeper Magnet
___ Neutron Walls
___ LENDA
___ Modular Neutron Array
___ Neutron Emission Ratio Observer
_X_ High Resolution Array
___ 53" Chamber
___ CsI(Na) Scintillator Array
___ Segmented Ge Array: [ ] classic; [ ] mini; [ ] beta; [ ] delta; [ ] barrel; [ ] other
___ S800 Spectrograph: [ ] with; [ ] without scattering chamber
___ Radio Frequency Fragment Separator
___ DDAS
___ Other (give details)

DETAIL ANY MODIFICATION TO THE STANDARD CONFIGURATION OF THE DEVICE USED, OR CHECK NONE: [X] NONE

DETAIL ANY REQUIREMENTS THAT ARE OUTSIDE THE CURRENT NSCL OPERATING ENVELOPE, OR CHECK NONE (Examples: vault reconfiguration, new primary beam, primary beam intensities above what is presently offered, special optics, operation at unusually high or low rigidities): [X] NONE

REACTION TARGETS AT EXPERIMENTAL STATION:

__$(CD_2)_n$ 1-2 mg/cm^2, ^{12}C 1-2mg/cm^2 ____

LIST ALL RESOURCES THAT YOU REQUEST THE NSCL TO PROVIDE FOR YOUR EXPERIMENT BEYOND THE STANDARD RESOURCES OUTLINED IN ITEM 12 OF THE NOTES FOR PAC 35 IN THE CALL FOR PROPOSALS. [ ] NONE

LIST ANY BREAKS REQUIRED IN THE SCHEDULE YOUR EXPERIMENT, OR CHECK NONE: (Examples of why an experiment might need an interruption: to change the experimental configuration; to complete the design of an experimental component based on an initial measurement.) [ ] NONE

OTHER SPECIAL REQUIREMENTS: (Safety related items are listed separately on following pages.) [ ] NONE

SUMMARY (no more than 200 words):
We propose to study the "super-heavy" hydrogen isotope ^{5}H using the (d,^{3}He) reaction in inverse kinematics with a 50 MeV/u ^{6}He beam using HiRA. Some properties of the ground-state resonance in ^{5}H have been reported; many experimental data are in conflict with each other, as well as with theoretical predictions. This study will provide a high-statistics measurement of the ground state of ^{5}H through the ^{6}He(d,^{3}He)^{5}H reaction at a higher bombarding energy and at more forward center-of-mass angles, improving the count rate and with better resolution in excitation energy than has been performed in the past, providing data with which to test earlier experimental and theoretical results for ^{5}H.

Description of Experiment

(no more than 4 pages of text for items 1through 3 - 1 1/2 spaced, 12pt; no limit on figures or tables)

Please organize material under the following headings or their equivalent:

1. Physics justification, including background and references.
2. Goals of proposed experiment
3. Experimental details—what is to be measured; technical feasibility of measurement; count rate estimate; basis of time request; discussion of present state of readiness of the experiment and an estimated earliest date for inclusion in the run schedule; discussion of any technical assistance (design, fabrication, installation, etc.) that may be requested from NSCL; apparatus (including sketch).

Note: Graphics should be such that black-and-white copies will convey the intended information correctly; references to color should be avoided.

I. Physics Justification

See attached.

II. Goals of the proposed experiment

See attached.

III. Experimental Details

See attached.

Physics Justification:

The possibility that the exotic isotope of hydrogen, ^{5}H, could exist as a long-lived system has been with us for more than 40 years. In 1963, Nefkens first suggested that a product of Li beta decay could be ^{5}H [1], launching a series of increasingly fruitless searches for a beta-stable ^{5}H (see, for example "*Still another unsuccessful search for ^{5}H*" [2] and references therein) which eventually concluded that ^{5}H cannot be formed as a particle-bound system. The possibility that ^{5}H could exist as a long-lived system capable as being observed as a particle-unbound resonant state has, however, survived. In 2001, Korshenninikov et al reported the observation of such a state in the ^{6}He(p,2p)^{5}H reaction [3], at an energy E_R=1.7 MeV above the ^{3}H+2n decay threshold, with a width of 1.9 MeV. (see Fig. 1a). Since that report, there have been several conflicting experimental results from a variety of reactions, all claiming different properties for the ground state of ^{5}H. In some cases, excited states have also been suggested.

Golovkov et al studied the ^{3}H(^{3}H,p)^{5}H reaction, finding a similar resonance energy(E_R=1.8 MeV), but claiming a significantly smaller width, limited by the experimental resolution, of Γ<0.5 MeV [4] (Fig. 2a). Excited states were also reported by the same group [5], and recently a detailed correlation analysis for the ^{3}H+2n decay products of ^{5}H populated in the ^{3}H(^{3}H,p)^{5}H reaction has been presented [6]. This narrow width is in conflict with most theoretical analyses of the ^{5}H system (see below). Interestingly, in [6] the ground-state energy and width are re-measured, and values of E_R=1.7 MeV and Γ=1.3 MeV are given.

In addition, Meister et al. reported proton knockout from ^{6}He on a ^{12}C target [7], with dramatically different conclusions about the resonance energy and width of E_R=2.5-3.0 MeV, and Γ=3-4 MeV (Fig 1b). Several reports of the ^{5}H ground state have also been made by Gornov et al, from pion absorption [8-10] with a variety of conclusions about the ground-state energy and width.

Another nucleon transfer reaction that has been used to populate ^{5}H is the proton-pickup reaction ^{6}He(d,^{3}He)^{5}H in inverse kinematics[11-13]. Results from (d,^{3}He) are also contradictory. Ref. [11] gives a resonance energy and width consistent with that in [4], while [12] gives a much larger width. Ref. [12] presents data from both ^{3}H(^{3}H,p)^{5}H and ^{6}He(d,^{3}He)^{5}H, and gives results that are in conflict with previous data. This might be surprising, since the data reported in [11-13] were obtained from experiment(s) done under very similar conditions, bombarding energies, and at the same laboratory. In 2004, Grigorenko reviewed the confusing state of the available data and concluded that "We find the current situation unsatisfactory, so a further clarification is due." [14].

Theoretically, most studies have utilized a cluster-model approach as a natural technique for dealing with this 3-body *t-n-n* system. As the experimental results have evolved, the theoretical conclusions have followed. Descouvement and Karbach [15] obtained cluster-model values for E_R and Γ that were consistent with the values reported in [3]. Similar results were reported in [16,17] where hyper-spherical harmonic and J-cluster approaches were used, respectively. Later, the cluster calculations of [15] were refined [18], yielding a smaller Γ consistent with the narrower peaks observed in ^{3}H(^{3}H,p)^{5}H, and one of the ^{6}He(d,^{3}He)^{5}H measurements. Barker, however, using an R-matrix approach, concluded that any such narrow resonance could not be accommodated theoretically [19].

Clearly, there is still considerable uncertainty regarding the nature of ^{5}H, and in our view the situation has not improved appreciably since Grigorenko's assessment of 2004. Therefore, we propose a new, independent measurement of the ^{6}He(d,^{3}He)^{5}H transfer reaction in inverse kinematics at the NSCL, with a 50 MeV/nucleon beam of ^{6}He, using HiRA.

Goals of the Experiment:

The goal of the measurement is to obtain a high-statistics data sample for the ^{6}He(d,^{3}He)^{5}H reaction to obtain an independent measurement of the resonance energy and width that can be compared with earlier results. The experimental signature for the ground-state resonance will be obtained by identifying coplanar ^{3}He-^{3}H coincidence events in HiRA following proton pickup from the ^{6}He beams on a deuterium target. The energy and width of the ground-state resonance will be obtained from the ^{3}He energy-angle kinematic correlations. The bombarding energy and center-of-mass angles covered will provide better statistics and improved resolution over previous measurements.

Experimental Details:

We propose to study ^{5}H using the (d,^{3}He) proton-pickup reaction in inverse kinematics with a ^{6}He beam from the NSCL A1900 separator at a secondary-beam bombarding energy of 50 MeV/u. The reaction products will be detected and identified using the HIRA charged-particle detector array [20]. HiRA will operate in the large S2 vault scattering chamber in a configuration with 14 telescopes, with the target situated 60 cm upstream of the target position. The kinematic relationship between energy and angle for the ^{3}He reaction products from the initial two-body transfer reaction determines the excitation energy of the residual ^{5}H nuclei. If formed, the heavy hydrogen nuclei will decay by neutron emission leaving ^{3}H nuclei as a decay product. The ^{3}H nuclei will be detected in HiRA in coincidence with ^{3}He ions. The emitted neutrons will not be detected. The reaction kinematics are such that the ^{3}He nuclei of interest, emitted at forward angles in the center-of-mass frame, have relatively low energy (<20 MeV) in the laboratory. There may also be significant yield at backward CM angles, however these ^{3}He have higher energies with a larger kinematic shift (see below) and we will focus on the low-energy branch. The tritons emerge with approximately the velocity of the parent heavy hydrogen, and high energies (between 100 and 250 MeV) in the laboratory. The full two-silicon-detector plus CsI telescope configuration of HIRA will be necessary to provide the necessary dynamic range for particle identification; ^{3}He ions will be detected and identified in the two silicon layers (with thicknesses of 65 μm and 1500 μm) while the tritons will be identified using the silicon detectors to measure energy loss (ΔE) and the CsI crystals to measure the residual energy E.

Figure 4 shows several aspects of the kinematics for the ^{6}He(d,^{3}He)^{5}H reactions from simple Monte Carlo simulations. These calculations are done only to show the kinematic correlations between the energies and angles of the ^{3}He and ^{3}H in the laboratory, and assume sequential neutron emission through a very broad intermediate ^{4}H state, and no further physics assumptions. "Simultaneous" decay scenarios produce ^{3}He and ^{3}H with similar energies. Various kinematic correlations will serve to identify the channels of interest in addition to the coincident identification of ^{3}He and ^{3}H. A signature for identification of ^{5}H will be ^{3}He ions that have an energy-angle relationship consistent with the expectations for the two-body reaction, and those ^{3}He are approximately co-planar ($\Delta\phi \sim 180^{o}$) with the detected ^{3}H ions (Fig. 4c). Although each emitted neutron provides a momentum "kick" to the resulting ^{3}H, due to the positive separation energies the effect is not enough to completely destroy the in plane correlation from the two-body reaction (Figs. 4c). At E(^{6}He)=50 MeV/u, the maximum ^{3}He angle in the laboratory, assuming a ^{5}H ground-state energy equal to that given in the literature, is 42^o. The angular distribution should be strongly peaked forward of 15^o in the center-of-mass frame (see below). HiRA will cover 1.5^o to 13^o (approximately 0.1^o to 7^o) in the laboratory where the cross section is large. The energy-angle correlation for the ^{3}H particles is shown in Fig. 4(b). The ^{3}H particles from the low-energy ^{3}He branch do not extend beyond 15^o, and we estimate that the efficiency for coincident ^{3}He-^{3}H detection is approximately 50%.

The size of the beam spot at the A1900 focal plane is estimated from LISE++ calculations to be approximately 5 mm FWHM, with a 90% envelope of approximately ± 5.4 mm. With HiRA at a distance of 60 cm from the target, this beam spot size produces an angular spread of approximately 1.5 degrees at forward angles. Without tracking of the incoming ^{6}He beam, due to the relatively small $dE(^3\mathrm{He})/d\theta$ of .08 MeV/degree, the contribution to the Q-value resolution for the (d,^{3}He) reaction is approximately 120 keV at forward center-of-mass angles less than 15 degrees.

Backgrounds:

The chief background in the measurements will be from the large number of alpha particles produced from breakup of the ^{6}He beam, and from the ^{12}C in the CD_2 target. The beam-related alpha particles are much more energetic than the ^{3}He of interest and should be readily separated. Low-energy alpha particles from the decay of excited ^{12}C nuclei generally have energies comparable to those of the ^{3}He particles of interest only if the ^{12}C is scattered at large angles, and these should not enter into the HiRA acceptance; the cross section for forward scattered ^{12}C ions is smaller, and the alpha particle energies are again greater than those of the ^{3}He ions of interest, and should also be separable. Any backgrounds that are associated with the ^{12}C present in the CD_2 target will be investigated by taking data with a pure ^{12}C target with each He beam.

Count rate estimate:

Count rate estimates are based on the following assumptions:

- The ^{6}He production rate, based on LISE++ calculations, is 3.2x10^5 particles per second, at the exit of the A1900 separator, with “focal plane slit” settings approximating the momentum acceptance of the following beam line. With these settings, the ^{6}He beam has no impurities. We assume an additional 50% loss for beam transmission, and use I(^{6}He)=1.6x10^5 pps on target.
- The HiRA solid angle is at 60 cm = 0.15 sr.
- The CM-to-laboratory solid-angle transformation factor is 2 for the ^{6}He induced reaction at the angles of interest.
- The target thickness is 2 mg/cm^2 (500 μg/cm^2 D_2) limited by straggling and energy loss of the low-energy ^{3}He ions so that the maximum contribution to the experimental resolution is ~ 80 keV FWHM, and the ^{3}He ions penetrate the 65 μm ΔE detectors with sufficient residual energy to be identified.

- The total ^{3}He-^{3}H coincidence detection efficiency is 50%.
- Guidance for estimates of the ^{6}He(d,^{3}He)^{5}H reaction cross sections can be taken from similar data on ^{4}He(d,^{3}He)^{3}H at comparable energies (Fig.5, Ref. [21]). There, the cross section for *s*-wave proton pickup is strongly energy dependent and peaked at 0^{o}. At low energies, the forward-angle cross section is less than 1 mb/sr, however where the momentum mismatch is small, the forward-angle cross section is greater than 10 mb/sr. The previous reports for ^{6}He(d,^{3}He)^{5}H at lower energies are vague about the expected cross section, but suggest values lower than those obtained from DWBA calculations. It is possible, or even likely that those measurements suffered from poor momentum matching conditions, and the situation will be improved at the higher bombarding energy. Also, in Ref. [12], the measurements were carried out away from 0^{o}, where the angular distribution should fall off considerably as in Fig. 5. Due to this uncertainty, however, we assume the cross section to be 1 mb/sr.

Under these assumptions, the count rate for the ^{2}H(^{6}He,^{3}He)^{5}H reaction would be approximately 0.2 counts per minute.

Basis of time request:

To obtain a statistically robust data set with enough events to subject the data to additional analysis cuts to improve the signal but may reduce the statistics, we wish to collect at least 1000-2000 counts for the ground-state transition of the ^{6}He induced reaction. Under the assumptions described above, we request 96 hours of ^{6}He beam on target. We will also need 24 additional hours of device tuning time with the ^{6}He beam, and 24 hours to investigate backgrounds using a ^{12}C target. Including development time of 17 hours for primary and secondary beam, the total request is 161 hours.

Other considerations:

The basic HiRA setup in the S2 vault is identical to that used in previous experiments (08001) and no additional mechanical development is needed for the HiRA support structure. In order to utilize the thin HiRA ΔE detectors in the S2 vault, additional supports must be fabricated to accommodate the preamplifier readout units. This support will be fabricated at WMU, however we will request 2-3 days of assistance to develop the designs for the additional preamplifier tower. This work will be coordinated with the HiRA mentors at NSCL. The in order to reduce device tuning time, the experiment could be run as part of a campaign with other HiRA experiments if they are approved with the same configuration. We expect to be ready to run by the summer of 2011.

References:

[1] B. M. K. Nefkens, Phys. Rev. Lett. **10**, 55 (1963).
[2] N. E. Booth et al., Nucl. Phys. A **119**, 233 (1968).
[3] A. A. Korsheninnikov et al., Phys. Rev. Lett. 87, 092501 (2001).
[4] M. S. Golovkov et al., Phys. Lett. B **566**, 70 (2003).
[5] M. S. Golovkov et al., Phys. Rev. Lett. **93**, 262501 (2004).
[6] M. S. Golovkov et al., Phys. Rev. C **72**, 064612 (2005).
[7] M. Meister et al., Phys. Rev. Lett. **91**, 162504 (2003).
[8] M. G. Gornov et al., Nucl. Phys. A **531**, 613 (1991).
[9] M. G. Gornov et al, Pis'ma Zh. Eksp. Teor. Fiz. **77**, 412 (1992).
[10] Yu. B. Gurov et al., Eur. Phys. Jour. A **24**, 231 (2005).
[11] S. Sidorchuck et al., Nucl. Phys. A 719, 229c (2003).
[12] S. Stepantsov et al., Nucl. Phys. A 738, 436 (2004).
[13] G. M. Ter-Akopian et al., Eur. Phys. J. A **25**, s01, 315 (2005).
[14] L. V. Grigorenko, Eur. Phys. J. A **20**, 419 (2004).
[15] P. Descouvemont and A. Karbach, Phys. Rev. C **63**, 027001 (2001).
[16] L.V. Grigorenko, N.K. Timofeyuk, M.V. Zhukov, Eur. Phys. J. A **19**, 181 (2004).
[17] J. Broeckhove et al., J. Phys. G **34**, 1955 (2007).
[18] F. C. Barker, Phys. Rev. C. **68**, 054602 (2003).
[19] A. Adachour and P. Descouvement, Nucl. Phys. A **813**, 252 (2008).
[20] M. S. Wallace et al., Nucl. Instrum. and Meth. A **583**, 302 (2007).
[21] B. Vuaridel *et al*., Nucl. Phys. A **484**, 34 (1988).

Figures:

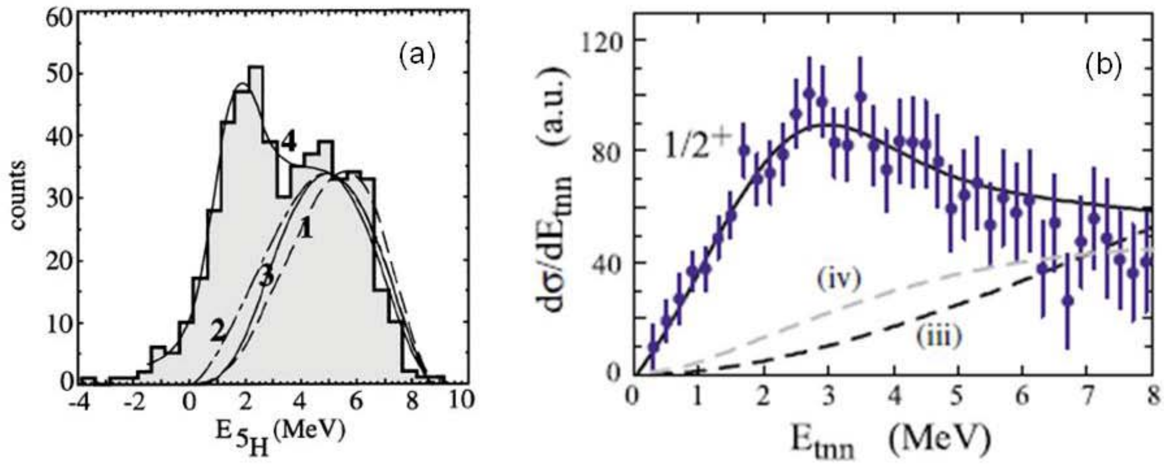

Figure 1. Evidence for the ground state of ^{5}H from (a) p(^{6}He,2p)^{5}H [3] and (b) ^{12}C(^{6}He,X)^{5}H [7].

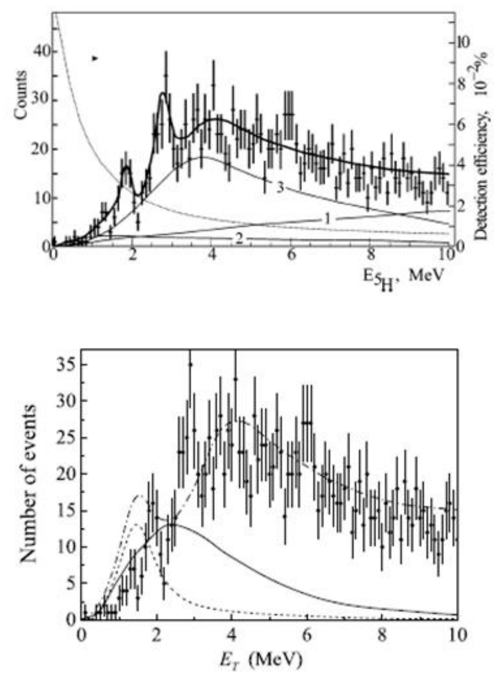

Figure 2. (top) ^{5}H excitation-energy spectrum from the ^{3}H(^{3}H,*p*)^{5}H reaction, from ref. [4]. (bottom) Same spectrum, only with different theoretical ^{5}H excitation curves overlaid.

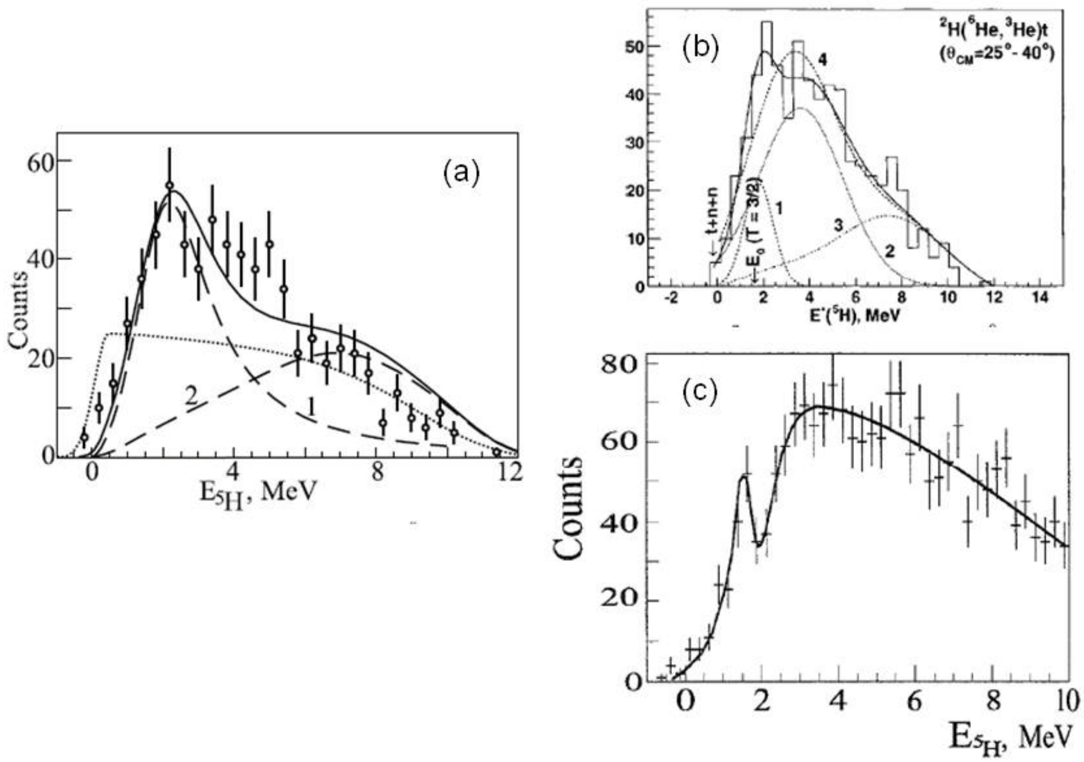

Figure 3. ^{5}H excitation spectra from the d(^{6}He,^{3}He)^{5}H reaction from (a) [11], (b) [12] and (c) [13].

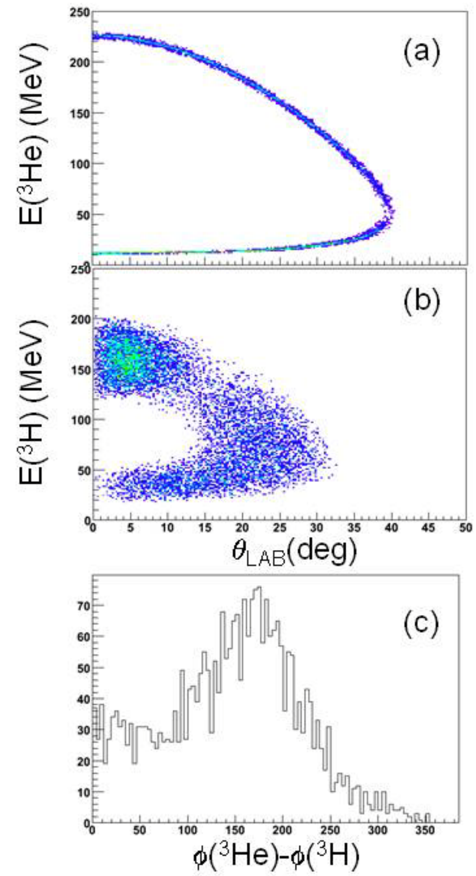

Figure 4. Monte Carlo simulations of kinematic correlations for the d(^{6}He,^{3}He)^{5}H reaction at 50 MeV/u. (a) Relationship between E(^{3}He) and θ(^{3}He); (b) Relationship between E(^{3}H) and θ(^{3}H); (c) co-planarity ϕ(^{3}He)-ϕ(^{3}H).

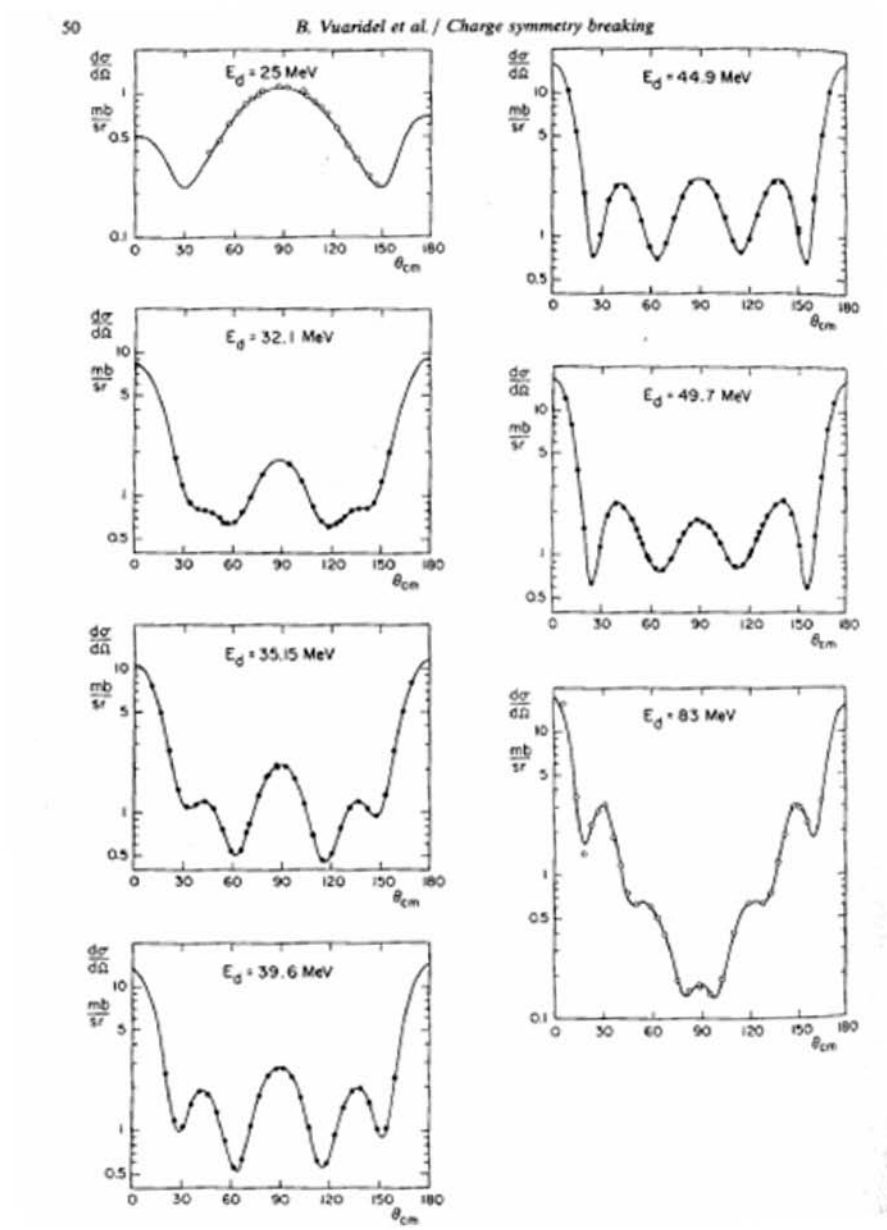

Figure 5. Angular distributions for the $^{4}He(d,^{3}He)^{3}H$ reaction at several bombarding energies, from [21].

Status of Previous Experiments

Results from, or status of analysis of, previous experiments at the CCF listed by experiment number. Please indicate publications, invited talks, Ph.D.s awarded, Master's degrees awarded, undergraduate theses completed.

None

Educational Impact of Proposed Experiment

If the experiment will be part of a thesis project, please include how many years the student has been in school, what other experiments the student has participated in at the NSCL and elsewhere (explicitly identify the experiments done as part of thesis work), and whether the proposed measurement will complete the thesis work.

This experiment will be the basis of the thesis project for Mr. Shadi Bedoor, graduate student at Western Michigan University. Mr. Bedoor has participated in experiments at Argonne National Laboratory and the NSCL.

Safety Information

It is an important goal of the NSCL that users perform their experiments safely, as emphasized in the Director's Safety Statement. Your proposal will be reviewed for safety issues by committees at the NSCL and MSU who will provide reviews to the PAC and to you. If your experiment is approved, a more detailed safety review will be required prior to scheduling and you will need to designate a Safety Representative for your experiment.

SAFETY CONTACT FOR THIS PROPOSAL:

____

HAZARD ASSESSMENTS (CHECK ALL ITEMS THAT MAY APPLY TO YOUR EXPERIMENT):

____X______ Radioactive sources required for checks or calibrations.
___________ Transport or send radioactive materials to or from the NSCL.
___________ Transport or send— to or from the NSCL—chemicals or materials that may be considered hazardous or toxic.
___________ Generate or dispose of chemicals or materials that may be considered hazardous or toxic.
___________ Mixed Waste (RCRA) will be generated and/or will need disposal.
___________ Flammable compressed gases needed.
___________ High-Voltage equipment (Non-standard equipment with > 30 Volts).
___________ User-supplied pressure or vacuum vessels, gas detectors.
___________ Non-ionizing radiation sources (microwave, class III or IV lasers, etc.).
___________ Biohazardous materials.
___________ Lifting or manipulating heavy equipment (>500 lbs)

PLEASE PROVIDE BRIEF DETAIL ABOUT EACH CHECKED ITEM.

Spectrograph Worksheet for S800 Spectrograph or Sweeper Magnet

The NSCL web site contains detailed technical information and service level descriptions about the S800 Spectrograph (Service Level Description) and the Sweeper Magnet (Service Level Description).

1. Timing detectors

Is a plastic timing scintillator required (at the object of the S800 or in front of the sweeper magnet)?

[ ] No
[ ] Yes

i. What is the desired thickness? [ ] 125 μm [ ] 1 mm [ ] other _____
ii. What maximum rate is expected on this scintillator? _______ Hz

2. Tracking detectors

Tracking detectors for incoming beam are available for Z>10. Performance limitations are to be expected at rates exceeding 200 kHz.

Are tracking detectors needed?

[ ] No
[ ] Yes

3. Focal-plane rates

a) What detectors are planned to be used?
b) What is the maximum rate expected in the focal-plane detection system? ____ Hz

4. For S800 experiments only: Optics mode and rigidities:

a) Which optics mode is needed?
[ ] Dispersion matched [ ] focused [ ] Other _________________________
b) What are the maximum and minimum rigidities planned to be used for the analysis beam line?
_____ Tm minimum, _____ Tm maximum
c) What are the maximum and minimum rigidity planned to be used for the spectrograph?
_____ Tm minimum, _____ Tm maximum
d) The maximum particle rate in the focal plane is 6 kHz when the CRDC detectors are being used. What is the maximum total particle rate expected in the S800 focal plane?
_____ Hz

Beam Request Worksheet Instructions

Please use a separate worksheet for each distinct beam-on-target requested for the experiment. Do not forget to include any beams needed for calibration or testing. This form does not apply for experiments based in the A1900. Note the following:

(a) **Beam Preparation Time** is the time required by the NSCL for beam development and beam delivery. This time is calculated as per item 5. of the Notes for PAC 35 in the Call for Proposals. This time is not part of the time available for performing the experiment.

(b) **Beam-On-Target Time** is the time that the beam is needed by experimenters for the purpose of performing the experiment, including such activities as experimental device tuning (for both supported and non-supported devices), debugging the experimental setup, calibrations, and test runs.

(c) The experimental device tuning time (XDT) for a supported device is calculated as per item 6. of the Notes for PAC 35 in the Call for Proposals. For a non-supported device, the contact person for the device can help in making the estimate. In general, XDT is needed only once per experiment but there are exceptions, e.g. a change of optics for the S800 will require a new XDT. When in doubt, please consult the appropriate contact person.

(d) A **primary beam** can be delivered as an on-target beam for the experiment either at the full beam energy or at a reduced energy by passing it through a degrader of appropriate thickness. The process of reducing the beam energy using a degrader necessarily reduces the quality of the beam. Please use a separate worksheet for each energy request from a single primary beam.

(e) Report the Beam-On-Target **rate** in units of particles per second per particle-nanoampere (pps/pnA) for secondary beams or in units of particle-nanoampere (pnA) for primary or degraded primary beams.

(f) More information about **momentum correction** and **timing start signal** rate limits are given in the A1900 service level description.

(g) For rare-isotope beam experiments, an electronic copy of the LISE++ files used to estimate the rare-isotope beam intensity must be e-mailed to the A1900 Device Contact.

Beam Request Worksheet

Please use a separate sheet for each distinct beam-on-target requested

	Beam Preparation Time	Beam-On-Target Time

Primary Beam (from beam list)

Isotope	^{18}O	
Energy	120	MeV/nucleon
Minimum intensity	150	particle-nanoampere

Tuning time (12 hrs; 0 hrs if the beam is already listed in an earlier worksheet): 12 hrs

Beam-On-Target

Isotope	^{6}He	
Energy	50	MeV/nucleon
Rate at A1900 focal plane	2.13×10^{3}	pps/pnA (secondary beam) or pnA (primary beam)
Total A1900 momentum acceptance	1%	% (e.g. 1%, not ±0.5%)
Minimum Acceptable purity	95%	%

Is a plastic timing scintillator required at the A1900 focal plane for providing a timing start signal?

[X] No

[ ] Yes

What is the desired thickness? [ ] 125 µm; [ ] 1000 µm

What is the maximum rate expected for this setting? __________Hz (1 MHz max)

Is event-by-event momentum correction from position measured at the A1900 Image 2 position required?

[X] No

[ ] Yes

Which detector should be used? [ ] Scintillator; [ ] PPACs

What is the maximum rate expected for this setting? __________Hz (1 MHz max)

Delivery time per table (or 0 hrs for primary/degraded primary beam): 2 hrs

Tuning time to vault: 3 hrs

Total beam preparation time for this beam: 17 hrs

Experimental device tuning time [see note (c) above]: 24 hrs

S800 [ ]; SeGA [ ]; Sweeper [ ]; Other [X] HiRA

On-target time excluding device tuning: 120 hrs

Total on-target time for this beam: 161 hrs